

CLAIMS

1. An apparatus for containing and delivering hazardous gases at sub-atmospheric pressure from a pressurized container, comprising:

- 5 (a) a valve body in sealed communication with an outlet orifice of the pressurized container, said outlet orifice of said pressurized container open to an interior chamber of said pressurized container;
- (b) a fluid discharge path in the valve body, between the outlet orifice of the pressurized container and an outlet orifice of the valve body;
- 10 (c) a pressure regulator having a pressure sensing means capable of responding to sub-atmospheric pressure, integral to said valve body, in-line in the fluid discharge path, said pressure regulator pre-set to a pressure below atmospheric pressure to allow said gas to be delivered through said regulator from said interior chamber only when said pressure sensing means senses a downstream pressure at or below said pre-set pressure; and
- 15 (d) a high pressure shut-off valve integral to said valve body, in-line in the fluid discharge path and upstream from said pressure regulator;

whereby said gas may flow through from said interior chamber of said pressurized container through said fluid discharge path, through said outlet orifice of said pressurized container, and through said outlet orifice of said valve body only when said outlet orifice is connected to a vacuum system.

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2. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, where the pressure regulator is preset and locked at the pressure below atmospheric.

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3. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, including a low pressure shut-off valve in-line in the fluid discharge path, downstream of the pressure regulator, to control flow of gas from the gas cylinder and to protect the regulator from ingress of ambient air during storage and transit when said low pressure shut-off valve is in a closed position.

4. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, where the high pressure shut-off valve is biased to be normally closed when no energized vacuum system is connected to said outlet orifice of the valve body.

5. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, including a filling path in the valve body between the outlet orifice of the pressurized container and a filling port orifice of the valve body.

6. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 5, including a residual pressure valve, in-line in the fluid discharge path, upstream of the high-pressure shut-off valve, to prevent back flow of air or foreign gases.

7. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 5, where the filling path does not coincide with the fluid discharge path.

8. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 5, where the filling path is a path that flows from a point on said fluid discharge path adjacent the outlet orifice upstream of said pressure regulator and upstream of said shut-off valve, to a point on said discharge path adjacent
5 said outlet orifice of said valve body.

9. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 5, wherein the filling port includes a keyed valve to prevent unauthorized access.

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10. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 5, wherein the filling port includes a keyed gas-tight outlet cap to prevent unauthorized access.

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11. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, wherein said pressure regulator is pre-set to a pressure of about -5 psig.

12. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, where said pressure regulator is preset at a fixed and
20 unchangeable regulator pressure below atmospheric pressure.

13. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, where said pressure regulator includes a means to
25 adjust said pre-set pressure.

14. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 13, where said means to adjust said pre-set pressure is keyed to prevent unauthorized access.

5 15. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, wherein the valve body is welded onto container to minimize any source of leakage of the gas in the pressurized container.

10 16. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, where apparatus utilizes modular components.

15 17. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, including a valve protection cap removably disposed on said pressurized container that serves as a secondary containment means for vapors leaking from the container and the apparatus.

20 18. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 17, where the valve protection cap has a port 35 to attach to a leak detection device.

25 19. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, wherein the vacuum system includes a compressor, wherein the vacuum system withdraws gas from the vessel at sub-atmospheric pressure and then compresses the gas to deliver said gas at a higher pressure.

20. An apparatus for containing and delivering hazardous gases at sub-atmospheric pressure from a pressurized container, comprising:

- (a) a valve body in sealed communication with an outlet orifice of the pressurized container, said outlet orifice of said pressurized container open to an interior chamber of said pressurized container;
- (b) a fluid discharge path in the valve body, between the outlet orifice of the pressurized container and an outlet orifice of the valve body;
- (c) a pressure regulator having a pressure sensing means capable of responding to sub-atmospheric pressure, integral to said valve body, in-line in the fluid discharge path, said pressure regulator pre-set to a pressure below atmospheric pressure to allow said gas to be delivered through said regulator from said interior chamber only when said pressure sensing means senses a downstream pressure at or below said pre-set pressure;
- (d) a high pressure shut-off valve integral to said valve body, in-line in the fluid discharge path and upstream from said pressure regulator;
- (e) a low pressure shut-off valve in-line in the fluid discharge path, downstream of the pressure regulator, to control flow of gas from the gas cylinder and to protect the regulator from ingress of ambient air during storage and transit when said low pressure shut-off valve is in a closed position; and
- (f) a filling path in the valve body between the outlet orifice of the pressurized container and a filling port orifice of the valve body;

whereby said gas may flow through from said interior chamber of said pressurized container through said fluid discharge path, through said outlet orifice of said pressurized container, and through said outlet orifice of said valve body only when said outlet orifice is connected to a vacuum system.

21. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, where the pressure regulator is preset and locked at the pressure below atmospheric.

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22. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, where the high pressure shut-off valve is biased to be normally closed when no energized vacuum system is connected to said outlet orifice of the container.

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23. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, including a residual pressure valve, in-line in the fluid discharge path, upstream of the high-pressure shut-off valve, to prevent back flow of air or foreign gases.

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24. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, where the filling path does not coincide with the fluid discharge path.

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25. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, where the filling path is a path that flows from a point on said fluid discharge path adjacent the outlet orifice upstream of said pressure regulator and upstream of said shut-off valve, to a point on said discharge path downstream of said outlet orifice of said valve body.

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26. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, wherein the filling port includes a keyed valve to prevent unauthorized access.

5 27. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, wherein the filling port includes a keyed gas-tight outlet cap to prevent unauthorized access.

10 28. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, wherein said pressure regulator is pre-set to a pressure of about -5 psig.

15 29. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, where said pressure regulator is preset at a fixed and unchangeable regulator pressure below atmospheric pressure.

20 30. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, where said pressure regulator includes a means to adjust said pre-set pressure.

31. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 30, where said means to adjust said pre-set pressure is keyed to prevent unauthorized access.

32. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, wherein the valve body is welded onto container to minimize any source of leakage of the gas in the pressurized container.

5 33. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, where apparatus utilizes modular components.

34. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, including a valve protection cap removably disposed
10 on said pressurized container that serves as a secondary containment means for vapors leaking from the container and the apparatus.

35. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 34, where the valve protection cap has a port to attach to
15 a leak detection device.

36. The apparatus for containing and delivering hazardous gases at sub-atmospheric pressure of claim 20, wherein the vacuum system includes a compressor, wherein the vacuum system withdraws gas from the vessel at sub-atmospheric pressure
20 and then compresses the gas to deliver said gas at a higher pressure.

37. An method for containing and delivering hazardous gases at sub-atmospheric pressure from a pressurized container, comprising:

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- (a) providing a valve body in sealed communication with an outlet orifice of the pressurized container, said outlet orifice of said pressurized container open to an interior chamber of said pressurized container;
- (b) providing a fluid discharge path in the valve body, between the outlet orifice of the pressurized container and an outlet orifice of the valve body;
- 10 (c) providing a pressure regulator having a pressure sensing means capable of responding to sub-atmospheric pressure, integral to said valve body, in-line in the fluid discharge path, said pressure regulator pre-set to a pressure below atmospheric pressure to allow said gas to be delivered through said regulator from said interior chamber only when said pressure sensing means senses a downstream pressure at or below said pre-set pressure; and
- (d) providing a high pressure shut-off valve integral to said valve body, in-line in the fluid discharge path and upstream from said pressure regulator;
- 15 (e) allowing said gas to flow through from said interior chamber of said pressurized container through said fluid discharge path, through said outlet orifice of said pressurized container, and through said outlet orifice of said valve body only when said outlet orifice is connected to a vacuum system.

20 38. The method for containing and delivering hazardous gases at sub-atmospheric pressure of claim 1, including the step of providing a low pressure shut-off valve in-line in the fluid discharge path, downstream of the pressure regulator, to control flow of gas from the gas cylinder and to protect the regulator from ingress of ambient air during storage and transit when said low pressure shut-off valve is in a closed position.

25 39. The method for containing and delivering hazardous gases at sub-atmospheric pressure of claim 38, including the step of providing an inert gas into the valve/regulator

assembly subsequent to use of the gas and prior to closing the low pressure valve to reduce the risk of air ingress into the valve/regulator assembly during transit.

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